

BIBLIOGRAPHY

on

CLEAN ROOMS

by the

Biological Sciences Communication Project

of

The George Washington University

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I. Preface

PREFACE

Millions of dollars and thousands of man-hours have been lost as a result of particulate contaminants. With the burgeoning growth of the electronics industry, newer techniques required newer standards of cleanliness; both were the off-spring of newer requirements laid down by the aerospace program of the National Aeronautics and Space Administration. In just a few short years the state of the art of contamination control has been refined and polished to a high degree of operational success.

As recently as the Korean War the army found that 75% of its electronic equipment was inoperable at any given time (Austin, 1965). Similar consequences were reported by the other military services. Under the added impetus of aerospace requirements, it was imperative that standards for clean rooms be established.

1963 proved to be a milestone year in the field of contamination control. In order to establish criteria for its own programs, the Air Force first published Tech. Order 00-25-203 in 1961. Revisions and reclassification brought out the revised technical order in 1963. At the same time, the Sandia Corporation of Albuquerque, New Mexico (a prime contractor to the Atomic Energy Commission) hosted a group of industry and government representatives who developed guidelines applicable to problems of contamination control. The final result was Federal Standard No. 209, revised in the summer of 1966 and released as FS 209a. Its objective is "to prescribe air cleanliness classes and other air environmental conditions required for achieving and maintaining the levels of cleanliness specified in the product specification" (FS 209a, 1966).

The history of clean room operations may be said to have had its beginnings in the last century with the struggle of Semmelweis to promote cleanliness in hospitals and the work of Lister in developing and promoting aseptic techniques. Over the years improvements in instruments, garments and sterilization techniques have been gradually accepted as standard in surgical suites. However, where the surgeon was concerned only with the control of infectious agents, the clean room worker was concerned with both viable and non-viable particulate matter.

The importance of contamination control is perhaps best realized by citing specifics: the two square meters of skin surface of an adult may release up to 30 million particles per sq. foot; exercise will increase this shedding rate even more. Average body movements produce one million particles per minute (Austin, 1966). Thus comes the realization that the human being is a continuous source of contaminants. To control this source of contamination requires the combined protective effects of proper clothing, techniques, design and operation.

The engineering contributions to the development and operation of clean rooms have been phenomenal. The use of HEPA (high efficiency particulate, air) filters reduces contamination by greater than 99%. Improved design and operation of ventilating systems have resulted in easier maintenance at lower cost. Instruments for detection of contaminants and for checking the efficiency of filters and clean room operation have been developed and refined. Proper use of air showers, garments and strict enforcement of rules have all contributed to the successful control of contaminating particles. Newer techniques of packaging reduce the number of contaminants released during handling and protect sensitive components from damaging humidity as well as dust.

Technological "feed-back" has enabled the medical profession and pharmaceutical industry to adopt techniques and methods originally designed for the aerospace industry. Indeed, such techniques may be required in the future by the cognizant federal agencies. Surgical suites benefit from improved knowledge of ventilating techniques, non-shedding, static-free garments and packaging and sterilization of instruments. Pharmaceutical houses have adopted clean room designs for their filling and packaging operations. Both benefit from the knowledge that personnel training and in-house regulations, rigidly controlled, can significantly reduce particulate "fall-out."

This bibliography on clean rooms was compiled in an effort to consolidate important developments for those persons involved in this rapidly advancing field of aerospace technology. Although the references cited are largely of work related to NASA-sponsored research, it is recognized that other government agencies such as the Food and Drug Administration, the Atomic Energy Commission, the Bureau of Standards and the Defense Department have supported research in clean room practices.

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III. Permuted Index

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